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[10191/2372]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s) : Joerg HEYSE
Serial No. : To Be Assigned
Filed : Herewith
For : FUEL INJECTOR
Examiner : To Be Assigned
Art Unit : To Be Assigned

Assistant Commissioner for Patents
Washington, D.C. 20231

**PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT**

S I R:

Kindly amend the above-captioned application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to:--WHAT IS CLAIMED IS:--.

Please cancel, without prejudice, claims 1 to 10 in the underlying PCT application.

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11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043 1044 10

17. (New) The fuel injector according to claim 15, wherein the valve-closure member includes a spherical arrangement and the blind hole has a cylindrical form.

18. (New) The fuel injector according to claim 17, wherein the blind hole extends along a longitudinal valve axis.

19. (New) The fuel injector according to claim 11, wherein the spray-discharge region having the at least one outlet opening as a base part of a valve-seat member having the valve seat is convexly curved.

20. (New). The fuel injector according to claim 11, wherein the fuel injector is configured to protrude into a combustion chamber of an externally ignited internal combustion engine.

21. (New) The fuel injector according to claim 11, wherein the fuel injector is configured to protrude into a combustion chamber of a self-igniting internal combustion engine.--.

REMARKS

This Preliminary Amendment cancels, without prejudice, claims 1 to 10 in the underlying PCT Application No. PCT/DE01/02709. This Preliminary Amendment adds new claims 11 to 21. The new claims, inter alia, conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §§ 1.121(b)(3)(iii) and 1.125(b)(2), a Marked-Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) is respectfully requested.

The underlying PCT Application No. PCT/DE01/02709 includes an International Search Report, dated December 28, 2001, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

It is respectfully submitted that the subject matter of the present application is new, non-obvious and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully submitted,

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PATENT TRADEMARK OFFICE

FUEL INJECTOR

[Background Information

] FIELD OF THE INVENTION

The present invention [is based on] relates to a fuel injector [of the type set forth in the main claim].

5

BACKGROUND INFORMATION

During operation of an engine, [the] a problem generally occurs in the case of direct injection of a fuel into the combustion chamber of an internal combustion engine, particularly in the case of direct gasoline injection or the injection of diesel fuel, that the downstream tip of the injection valve projecting into the combustion chamber is coked by fuel deposits or that soot particles formed in the flame front are deposited on the valve tip. Therefore, in the [case] conventional arrangement of injection valves projecting into the combustion chamber [known heretofore], there is the danger during its lifetime of a negative influence on the spray parameter (e.g., static flow quantity, spray angle, drop size, skeining) that can lead to operational disturbances of the internal combustion engine or to a malfunction of the injection valve.

[Summary of the Invention

] SUMMARY

The injector valve [of] according to the present invention [having] may provide that the [characterizing features of the main claim has the advantage that these previously mentioned] negative effects of coking (soot depositing) [especially], e.g., on the valve tip projecting into the combustion chamber including its outlet openings [is], may be restricted or eliminated. Forming a device for accumulating

combustion-chamber gas with access to the dead volume
[situated] arranged between valve needle end and the spray
region including the outlet openings in accordance with the
present invention makes it possible to largely prevent coke
5 deposits in the outlet openings. The buoyancy of the gas phase
with respect to the liquid phase causes the gas to remain in
the device for accumulating combustion chamber gas.

10 In this manner, the spray parameter and the valve function are
able to be maintained in a stable manner during its entire
lifetime even in the case of direct injection of fuel into a
combustion chamber at the fuel injection valves.

15 [The measures specified in the subclaims permit advantageous
further developments and improvements of the fuel injector
indicated in the main claim.

20 It is advantageous to provide one] One or more blind holes may
be provided on the valve needle end facing the outlet
openings, i.e., on the surface of the valve-closure member
facing the dead volume. In this context, it [must] may be
ensured that the blind holes have access to the dead volume
and that the gas volume is not able to escape from the gas
accumulation volume by buoyancy force.

25 [Brief Description of the Drawing

30 An exemplary] An example embodiment of the present invention
is represented in simplified form in the drawing, and is
explained in detail in the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

35 Figure 1 [shows] is a cross-sectional view of a part of a fuel
injector[, and].

Figure 2 [shows] is a schematic [section] cross-sectional view of an outlet opening having a breaking-off liquid column [situated] arranged therein.

5 [Description of the Exemplary Embodiments

] DETAILED DESCRIPTION

Figure 1 partially [shows] illustrates a valve in the form of an injection valve for fuel injection systems of mixture-compressing, externally ignited internal combustion
10 engines as an [exemplary] example embodiment. The injection valve has a tubular valve-seat support 1, in which a longitudinal opening 3 is formed concentrically to a longitudinal valve axis 2. [Situated] Arranged in longitudinal opening 3 is a, for example, tubular valve needle 5, which is
15 securely connected at [its] a downstream end 6 to a, for example, spherical valve closure member 7, on [whose] the periphery of which, for example, five flattenings 8 are provided for the fuel to flow past.

20 The fuel injector is actuated in a [known] conventional manner, e.g., electromagnetically. A schematically indicated electromagnetic circuit having magnetic coil 10, an armature 11, and an core 12 is used for axially moving valve needle 5, and as such, for opening the fuel injector against the spring
25 force of a restoring spring [(not shown)] and for closing the fuel injector. Armature 11 is connected, for example, by a welded seam formed by a laser to the end of valve needle 5 away from valve-closure member 7, and is aligned with core 12.

30 A guide opening 15 of a valve-seat member 16, which is sealingly mounted by welding in the downstream end of valve-seat support 1 away from core 12, in longitudinal opening 3, which [runs] extends concentrically to longitudinal valve axis 2, is used for guiding valve-closure member 7
35 during the axial movement. Valve-seat member 16 has a cupped

[design] configuration, for example, a jacket part 17 of valve-seat member 16 transitioning in the direction of armature 11 into a collar 18 abutting against valve-seat support 1. On the side opposite collar 18, valve-seat member

5 16 has a base part 19, which is convexly curved, for example.

The insertion depth of valve-seat member 16 determines the magnitude of the lift of valve needle 5 since the one end position of valve needle 5 in the case of a non-energized

10 magnetic coil 10 is determined by the seating of valve-closure member 7 at valve-seat surface 22, which tapers conically in a downstream direction or has a slightly curved [design] configuration, on base part 19 of valve-seat member 16. Given an energized magnetic coil 10, the other end position of valve

15 needle 5 is determined, e.g., by the seating of armature 11 on core 12. [Therefore, the] The path between these two end positions of valve needle 5 represents the lift. Spherical valve-closure member 7 cooperates with truncated-cone-shaped or curved valve-seat surface 22 of valve-seat member 16, which

20 is formed between guide opening 15 and a plurality of outlet openings 23 inserted in a central region of base part 19 of valve-seat member 16. Base part 19 forms the spray-discharge region of the fuel injector.

25 In particular, the fuel injector is [designed] configured as a so-called multi-hole valve that is particularly suited for injecting fuel directly into a combustion chamber[(not shown)]. In this context, at least [2] two or also four or significantly more outlet openings 23 are inserted in base

30 part 19 of valve-seat member 16, e.g., via erosive machining, laser drilling, [or] punching, etc. For a desired filling of the combustion chamber with fuel, outlet openings 23 are aligned, for example, at different angles to longitudinal valve axis 2, all outlet openings 23, for example, moving away

35 from longitudinal valve axis 2 in the downstream direction at an angle.

Especially such multi-hole valves for directly injecting fuel into a combustion chamber [whose] the outlet openings of which are directly subjected to the combustion chamber atmosphere are extremely susceptible to coking. [In an unfavorable case, such] Such outlet openings may have build-up on their periphery due to coke deposits, thereby making it impossible for the desired injection quantities to be dosed and metered in acceptable amounts.

The fuel injector [of] according to the present invention [is to] may largely prevent coke deposits of the combustion chamber in the region of outlet openings 23 from obstructing the outlet openings and significantly changing the injection quantities during the valve's lifetime.

Since valve-closure member 7 and curved base part 19 of valve-seat member 16 are formed with different radii, there is, when the injector valve is closed, an enclosed space representing a dead volume 25 within annular valve-seat surface 22 in the region of outlet openings 23, between valve-closure member 7 and base part 19. In accordance with the present invention, gas is to be accumulated in dead volume 25 in order to prevent coke deposits at outlet openings 23. Before this functional principle of gas accumulation is described, the creation of coke deposits is to be briefly explained [in the following].

The processes of through-flow and coking are subsequently explained [on the basis of] with reference to Figure 2, which schematically [shows] illustrates an outlet opening 23. When valve-closure member 7 is pressed back at the end of the injection operation onto valve-seat surface 22, the flow through outlet openings 23 is stopped abruptly. Therefore, no more fuel continues to flow through the sealing seat region past valve-seat surface 22 into dead volume 25.

Due to its weight, liquid column 27, which is emerging from outlet openings 23 immediately prior to the closing of the valve, possesses a certain inertia. The low pressure in liquid column 27 produced as a result of the closing of the valve and of the associated stop of the flow in the sealing seat region becomes greater as a function of inertia starting from an outlet plane 28 of outlet opening 23 in the downstream direction within outlet opening 23. At a certain location 29 within liquid column 27, the vapor pressure of the liquid is insufficient. A vapor phase forms suddenly at this location 29, thereby causing part 30 of liquid column 27, which is downstream of this location 29, to break away from the remaining liquid as a result of inertia.

A meniscus of liquid at which there is a phase boundary between the liquid and the gas surrounding the valve forms within outlet opening 23. When injecting fuel directly into a combustion chamber, all components directly on the combustion chamber, therefore also a direct injection valve, in particular outlet openings 23, which project into the combustion chamber, are subjected to an extreme influence of heat. During combustion, coke residues may form on the above-mentioned phase boundary in particular and build-up on the wall of outlet opening 23, thereby resulting in the previously explained disadvantages. Consequently, in the case of [known] conventional valves, annular coke deposits that disadvantageously constrict flow result at a certain depth in outlet openings 23.

In the [design] configuration of the fuel injector [of] according to the present invention, outlet openings 23 are completely emptied for which reason no coke deposits are able to form within outlet openings 23. In accordance with the present invention, a device for gas accumulation is, therefore, produced directly at dead volume 25. In the [exemplary] example embodiment [shown] illustrated in Figure

1, this device for gas accumulation is [designed] configured
as central blind hole 33 in valve-closure member 7 on its
surface facing dead volume 25. Blind hole 33 is filled with
combustion chamber gas, i.e., with the air dissolved in the
5 fuel. The buoyancy of the gas phase with respect to the liquid
phase causes the gas to remain in blind hole 33.

When opening the valve by raising valve-closure member 7 from
valve-seat surface 22, the fluid pressure in dead volume 25
10 increases, thereby compressing the gas volume in blind hole
33. In this context, the gas is pressed further into blind
hole 33. When closing the valve, the fluid pressure decreases
again, and the gas volume expands again within blind hole 33.
Since additional fluid is prevented from flowing into dead
15 volume 25 when the valve is closed, an underpressure is
produced in the liquid phase as a result of the inertia of the
just emerged fluid. As a result, the gas volume of blind hole
33 is able to expand even further, so that it partially
reaches into dead volume 25. The fluid volume expelled in this
20 manner is able to flow out of outlet opening 23.

While a pressure equilibrium returns in dead volume 25, the
remaining fluid volume recedes from outlet openings 23 into
dead volume 25 as a result of a contraction of the gas phase.
25 Outlet openings 23 fill completely with combustion chamber
gas. The liquid column disappears completely from outlet
openings 23. In this manner, there is also no more meniscus of
liquid column 27 in outlet opening 23 for which reason
disadvantageous, annular coking deposits are also not able to
30 form in outlet opening 23.

Instead of an individual blind hole 33, a plurality of smaller
blind holes 33 may also be provided next to one another on the
valve needle end facing outlet openings 23, i.e., on
35 valve-closure member 7. This [has] arrangement may provide the
advantage that given the same gas accumulation volume, the

The valve needle tip, i.e., valve-closure member 7 is not the only component part of the fuel injector on which blind holes of the present invention are able to be formed. Rather, it [must] may be ensured that blind holes 33 have access to dead volume 25 and that the gas volume is not able to escape from the gas accumulation volume by buoyancy force.

[Abstract

] **ABSTRACT**

[The present invention relates to a] **A** fuel injector, in particular a fuel injector protruding directly into a combustion chamber of an internal combustion engine, [having] **includes** an energizable actuator[(10, 11, 12)], a valve-closure member [(7)] able to be moved by the actuator[(10, 11, 12)], a secure valve seat[(22)], with which the valve-closure member [(7)] cooperates to open and close the valve, a fuel outlet formed in a downstream spray-discharge region and by at least one outlet opening [(23) situated] **arranged** downstream from valve seat[(22)], and a dead volume [(25)] formed downstream from valve seat [(22)] and upstream from the spray-discharge region having at least one outlet opening[(23)]. A device for accumulating combustion chamber gas is provided in the valve-closure member [(7)] in the form of a blind hole [(33)] having direct access to the dead volume[(25)].[

(Figure 1)]

FUEL INJECTOR

FIELD OF THE INVENTION

The present invention relates to a fuel injector.

BACKGROUND INFORMATION

5 During operation of an engine, a problem generally occurs in the case of direct injection of a fuel into the combustion chamber of an internal combustion engine, particularly in the case of direct gasoline injection or the injection of diesel fuel, that the downstream tip of the injection valve
10 projecting into the combustion chamber is coked by fuel deposits or that soot particles formed in the flame front are deposited on the valve tip. Therefore, in the conventional arrangement of injection valves projecting into the combustion chamber, there is the danger during its lifetime of a negative
15 influence on the spray parameter (e.g., static flow quantity, spray angle, drop size, skeining) that can lead to operational disturbances of the internal combustion engine or to a malfunction of the injection valve.

20 SUMMARY

The injector valve according to the present invention may provide that the negative effects of coking (soot depositing), e.g., on the valve tip projecting into the combustion chamber including its outlet openings, may be restricted or
25 eliminated. Forming a device for accumulating combustion-chamber gas with access to the dead volume arranged between valve needle end and the spray region including the outlet openings in accordance with the present invention makes it possible to largely prevent coke deposits in the outlet
30 openings. The buoyancy of the gas phase with respect to the liquid phase causes the gas to remain in the device for accumulating combustion chamber gas.

member 16. Base part 19 forms the spray-discharge region of the fuel injector.

In particular, the fuel injector is configured as a so-called multi-hole valve that is particularly suited for injecting fuel directly into a combustion chamber. In this context, at least two or also four or significantly more outlet openings 23 are inserted in base part 19 of valve-seat member 16, e.g., via erosive machining, laser drilling, punching, etc. For a desired filling of the combustion chamber with fuel, outlet openings 23 are aligned, for example, at different angles to longitudinal valve axis 2, all outlet openings 23, for example, moving away from longitudinal valve axis 2 in the downstream direction at an angle.

Especially such multi-hole valves for directly injecting fuel into a combustion chamber the outlet openings of which are directly subjected to the combustion chamber atmosphere are extremely susceptible to coking. Such outlet openings may have build-up on their periphery due to coke deposits, thereby making it impossible for the desired injection quantities to be dosed and metered in acceptable amounts.

The fuel injector according to the present invention may largely prevent coke deposits of the combustion chamber in the region of outlet openings 23 from obstructing the outlet openings and significantly changing the injection quantities during the valve's lifetime.

Since valve-closure member 7 and curved base part 19 of valve-seat member 16 are formed with different radii, there is, when the injector valve is closed, an enclosed space representing a dead volume 25 within annular valve-seat surface 22 in the region of outlet openings 23, between valve-closure member 7 and base part 19. In accordance with the present invention, gas is to be accumulated in dead volume 25 in order to prevent coke deposits at outlet openings 23.

Before this functional principle of gas accumulation is described, the creation of coke deposits is to be briefly explained.

5 The processes of through-flow and coking are subsequently explained with reference to Figure 2, which schematically illustrates an outlet opening 23. When valve-closure member 7 is pressed back at the end of the injection operation onto valve-seat surface 22, the flow through outlet openings 23 is
10 stopped abruptly. Therefore, no more fuel continues to flow through the sealing seat region past valve-seat surface 22 into dead volume 25.

Due to its weight, liquid column 27, which is emerging from
15 outlet openings 23 immediately prior to the closing of the valve, possesses a certain inertia. The low pressure in liquid column 27 produced as a result of the closing of the valve and of the associated stop of the flow in the sealing seat region becomes greater as a function of inertia starting from an
20 outlet plane 28 of outlet opening 23 in the downstream direction within outlet opening 23. At a certain location 29 within liquid column 27, the vapor pressure of the liquid is insufficient. A vapor phase forms suddenly at this location 29, thereby causing part 30 of liquid column 27, which is
25 downstream of this location 29, to break away from the remaining liquid as a result of inertia.

A meniscus of liquid at which there is a phase boundary between the liquid and the gas surrounding the valve forms
30 within outlet opening 23. When injecting fuel directly into a combustion chamber, all components directly on the combustion chamber, therefore also a direct injection valve, in particular outlet openings 23, which project into the combustion chamber, are subjected to an extreme influence of
35 heat. During combustion, coke residues may form on the above-mentioned phase boundary in particular and build-up on the wall of outlet opening 23, thereby resulting in the

previously explained disadvantages. Consequently, in the case of conventional valves, annular coke deposits that disadvantageously constrict flow result at a certain depth in outlet openings 23.

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In the configuration of the fuel injector according to the present invention, outlet openings 23 are completely emptied for which reason no coke deposits are able to form within outlet openings 23. In accordance with the present invention, a device for gas accumulation is, therefore, produced directly at dead volume 25. In the example embodiment illustrated in Figure 1, this device for gas accumulation is configured as central blind hole 33 in valve-closure member 7 on its surface facing dead volume 25. Blind hole 33 is filled with combustion chamber gas, i.e., with the air dissolved in the fuel. The buoyancy of the gas phase with respect to the liquid phase causes the gas to remain in blind hole 33.

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When opening the valve by raising valve-closure member 7 from valve-seat surface 22, the fluid pressure in dead volume 25 increases, thereby compressing the gas volume in blind hole 33. In this context, the gas is pressed further into blind hole 33. When closing the valve, the fluid pressure decreases again, and the gas volume expands again within blind hole 33. Since additional fluid is prevented from flowing into dead volume 25 when the valve is closed, an underpressure is produced in the liquid phase as a result of the inertia of the just emerged fluid. As a result, the gas volume of blind hole 33 is able to expand even further, so that it partially reaches into dead volume 25. The fluid volume expelled in this manner is able to flow out of outlet opening 23.

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While a pressure equilibrium returns in dead volume 25, the remaining fluid volume recedes from outlet openings 23 into dead volume 25 as a result of a contraction of the gas phase. Outlet openings 23 fill completely with combustion chamber gas. The liquid column disappears completely from outlet

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openings 23. In this manner, there is also no more meniscus of liquid column 27 in outlet opening 23 for which reason disadvantageous, annular coking deposits are also not able to form in outlet opening 23.

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Instead of an individual blind hole 33, a plurality of smaller blind holes 33 may also be provided next to one another on the valve needle end facing outlet openings 23, i.e., on valve-closure member 7. This arrangement may provide the advantage that given the same gas accumulation volume, the cross section of individual blind holes 33 is smaller and, consequently, the capillary effect in blind holes 33 increases. Therefore, the accumulated gas is even less able to be expelled by flow forces of the liquid.

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The valve needle tip, i.e., valve-closure member 7 is not the only component part of the fuel injector on which blind holes of the present invention are able to be formed. Rather, it may be ensured that blind holes 33 have access to dead volume 25 and that the gas volume is not able to escape from the gas accumulation volume by buoyancy force.

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